METHOD FOR JOINT USE OF A RADIO ACCESS NETWORK BY SEVERAL MOBILE RADIO PROVIDERS

[0001] The present invention relates to a method that allows several providers of mobile radio services to jointly use a radio access network of a mobile radio system. Several reasons (for example financial or regulatory) nowadays force mobile radio providers to efficiently utilize, jointly operate or share parts of the infrastructure for providing mobile radio services.

[0002] The present state-of-the-art is reflected in national roaming agreements, where the mobile radio subscribers of one mobile radio operator are permitted to use the mobile access network and also the core network of the respective roaming partner. The methods for providing these roaming services are mainly based on standardized methods, for example of the 3GPP standard [www.3gpp.org]. In addition, the currently employed linkage between radio access network and the core network of a mobile radio provider makes it impossible to select another core network, for example a Mobile Switching Center (MSC) for providing circuit-switched (CS) connections, for example for voice connections, or another Serving GPRS Node (SGSN) for providing packet-switched (PS) connections, for example Internet access. The basic architecture of a conventional mobile radio network is shown in Fig. 1. The radio access networks (RAN) 4, 5 and the respective core networks (CN) 1, 2 of the mobile radio operator A and B are implemented in both (or several) mobile radio operators in parallel. If roaming agreements between the mobile radio operators exist, the mobile radio subscribers of operator A can, for example, use in areas without mobile radio service by operator A the mobile radio services of operator B via its radio access and core network 4, 2. However, in this case, the operator B provides all the services for the mobile radio subscriber of A. This situation has, *inter alia*, the disadvantage that the operators A and B must reconcile the rendered mobile radio services; however, operator B may not be able to offer all the services offered by operator A. Frequently, national roaming agreements, in which mobile radio operators lacking an equal market position may enter, may therefore be one-sided.

[0003] It is therefore an object of the present invention to enable a more efficiently utilization of the infrastructure of mobile radio networks of different operators to, on one hand, increase the economic value and, on the other hand, to better satisfy environmental requirements and regulations.

[0004] This object is solved by the features of claims 1 and 25, to which reference is being made.

[0005] Preferred and advantageous embodiments of the invention are recited in the dependent claims 2 to 14 and 26 to 28, to which reference is being made.

[0006] The method of the invention makes is possible to provide different mobile radio providers with access to a common radio access network. A mobile radio subscriber selects a single ID from several IDs, preferably PLMN IDs, which are transmitted by a common radio access network, and uses services (CS or PS) via the associated core network of the selected mobile radio operator. The present invention represents a significant improvement over the state-of-the-art, because it allows the use of a common radio access network (RAN) and provides separate core networks (CN) for the different mobile radio operators.

[0007] Preferred embodiments of the invention will now be described with reference to the drawings.

[0008] Fig. 1 shows schematically an exemplary architecture of two conventional mobile radio networks operating side-by-side;

[0009] Fig. 2 shows the basic configuration or architecture of two mobile radio systems with a jointly used mobile radio access network according to the invention;

[0010] Fig. 3 shows an embodiment of the system according to Fig. 2;

[0011] Fig. 4a shows conventional MIB and SIB1 transmission on BCCH;

[0012] Fig. 4b shows additional PLMN IDs transmitted in the MIB on the BCCH;

[0013] Fig. 4c shows additional PLMN IDs transmitted in the SIB1;

[0014] Fig. 4d shows additional PLMN IDs transmitted in the MIB and additional SIB1 per PLMN;

[0015] Fig. 4e shows additional PLMN IDs transmitted in the MIB and additional SIB1 per PLMN for each supported PLMN; and

[0016] Fig. 4f shows introduction of entirely new MIBs and SIB1 for each supported PLMN.

[0017] The present invention provides a basic configuration or architecture of the mobile radio access and core network, as shown in Fig. 2. In this embodiment, a single common radio access network 9, for example operating according to the UMTS or GSM standard, is connected to two (or more) core networks 6, 7, with the core network providing the services of the respective selected mobile radio operator to the mobile radio subscriber. However, this core network is accessed via the jointly used radio access network, whereas the service in the core network is separate. In a conventional system architecture depicted in Fig. 1, a mobile radio subscriber can obtain only the services of a single mobile radio provider, which depends on the employed radio access network 5 or 4 (the actual mobile radio operator is selected by selecting the radio access network). The respective radio access network must be switched when using the services of another mobile radio operator, because a conventional radio access network 5 or 4 permits access only to exactly one radio network 1 or 2 of the corresponding operator. A mobile radio subscriber then also has available only the PS and CS core network elements of the one radio access network operator.

[0018] The identity of the mobile radio operator is currently signaled to all potential mobile radio subscribers in the reception area of the radio access network by transmitting a so-called operator ID (Public Land Mobile Network Identity - PLMN ID) on an organization channel (Broadcast Control Channel - BCCH). Following activation, the subscriber terminal (mobile station "MS" in GSM, or user equipment "UE" in UMTS) selects the mobile radio network and requests services ("PLMN selection") from the selected mobile radio network following standardized procedures [e.g., 3GPP TS 22.011]. The selection of the mobile radio operators is based on the existence of a unique ID (PLMN ID) on the BCCH of each mobile radio access network. Conventional systems are not capable of transmitting more than one mobile radio network operator ID (PLMN ID) on the BCCH of a mobile radio access network.

[0019] Conversely, with the method according to the invention, the mobile radio subscriber or, in automatic mode [e.g., 3GPP TS 23.122], the subscriber terminal itself can select the core network, and thereby the desired mobile radio operator, based on the transmission of additional PLMN IDs on the BCCH of the radio access network, without having to switch between radio access networks. According to the invention, several core networks are connected to one radio access network.

[0020] This is the basic principle of the inventive method and is depicted in Fig. 3.

[0021] Transmission of the PLMN ID 14 of the radio access network 12 and thus of the operator of the mobile radio system is described, for example, in [3GPP TS 04.18] for a system operating according to the GSM standard, and in [3GPP TS 25.331] for a mobile radio system operating according to the UMTS standard. Both standards use the organization channel (BCCH) for transmitting this information. In a mobile radio system operating according to the GSM standard, the PLMN ID is transmitted in System Information type 3; in a mobile radio system operating according to the UMTS standard, in Master Information Block (MIB). Both systems have in common that network ID (PLMN ID) are comprised of a sequence of numbers (digits) having the format "abc-xyz." "abc" herein designates a so-called Mobile Country Code (MCC) which indicates to the subscriber terminal 13 the applicable country (for example "262" for Germany),

whereas "xyz" indicates the Mobile Network Code (MNC) for the various mobile radio operators within a country (for example "01" for T-Mobile D in Germany). In many other countries MNCs can have 2 or 3 digits. The systems operating according to the UMTS and GSM standards having common that the PLMN ID repeats on the organization channel BCCH on a regular basis, so that mobile radio terminals 13 have information available about the identity of the mobile radio network within a reasonably time. For example, in the UMTS standard, the MIB is repeated every 8 BCCH-blocks, as indicated in Fig. 4a.

[0022] According to [3GPP TS 25.331], the MIB for the BCCH has the following structure:

[0023] | **MIB**

-->PLMN id

-->MCC

-->MCN

[0024] | (other information)

[0025] With this conventional structure [3GPP TS 25.331], only a single mobile radio network ID 14, i.e., a combination of MCC & MCN, can be transmitted to the subscriber terminal 13.

[0026] According to the method of the invention, more than one PLMN ID can be transmitted in the MIB, so that several core networks 10, 11 can be announced over a common radio access network 12 and reached by a subscriber terminal 13.

[0027] A MIB according to the method of the invention could, for example, have the following structure:

[0028] | **MIB**

-->PLMN id**1**

-->MCC

-->MCN

-->PLMN id2

-->MCC

-->MCN

-->PLMN id"n"1

-->MCC

-->MCN

[0029] | (other information)

[0030] With this structure of the MIB on the organization channel BCCH, more than one PLMN ID can be transmitted to each subscriber terminal within the mobile radio access network for selection (illustrated in Fig. 4b). Alternatively to the announcement of additional PLMN IDs, a different System Information Block (SIB) of the BCCH can be used, for example the System Information Block 1 (SIB1), as shown in Fig. 4c. This block is typically used to announce core network information [3GPP TS 25.331]. In principle, the information can here also be expanded by additional PLMN IDs, for example by transmitting in the SIB1 the PLMN ID 2, PLMN ID 3, etc. Moreover, one or several additional MIBs can be defined which include all the information of conventional methods for the respective additional PLMN IDs (Fig. 4f).

[0031] According to an additional important feature of the present invention, the exclusivity of the selected mobile radio operator is maintained. In other words: a mobile radio terminal 13 must select a single mobile radio operator from the offered number of mobile radio operators which then provides the services. This does not prevent the mobile radio terminal (or the user) 13 from switching the mobile radio operator 10, 11; however, the mobile access network 12 itself is not switched.

[0032] Conventional systems have the additional disadvantage that they are unable to indicate to the radio access network control unit (in UMTS: Radio Network Controller - RNC; in GSM: Base Station Controller - BSC) the particular core network 10, 11 to which a mobile radio terminal 13 wants to be connected. The RNC/BSC must be informed upon registration, with which of the possible core networks (which in this case are synonymous with mobile radio operators) 10, 11 the registration should be completed. The RNC/BSC sets up the connection to the corresponding core networks 10, 11 based on the selection by the subscriber terminal 13 (for example via the Iu-interface 8 in UMTS systems), with registration then implemented according to the conventional UMTS and GSM standard, respectively.

[0033] As described above, the subscriber terminal 13 must be informed of the existence

of several core networks 10, 11 or mobile radio operators within a radio access network 12 and must have made a decision to register with a single network, based on the PLMN identity. The subscriber terminal must also inform the RNC/BSC 15 during the registration process of the selection among the possible mobile radio operators 10, 11 (based on the PLMN ID). Various implementation modes are feasible:

[0034] To register a subscriber terminal 13 in a mobile radio network 10 or 11, a subscriber terminal 13 must communicate with the radio access network control unit (RNC/BSC) (in 12). In conventional mobile radio systems, the radio access network control unit (RNC/BSC) (in 12) does not need to be informed of the selected PLMN 10 or 11, since only one possibility exist for the core network 10, 11, because the entire core network is operated by the operator of the radio access network. Conversely, with the inventive method, the radio access network control unit (RNC/BSC) (in 12) must also be informed of the core network elements 10 or 11, to which a connection is to be set up for the purpose of registration.

[0035] In UMTS systems, the subscriber terminal 13 sets up the connection via a RRC CONNECTION REQUEST message [3GPP TS 25.331], which can advantageously be used to transmit 15 the identification of the selected PLMNs 10 or 11, i.e., of the mobile radio operator, from the subscriber terminal 13 to the radio access network control unit (RNC/BSC) (in 12). The information about the selected PLMN must be transmitted 15 in this message or in another message, for example, in the form of MCC or MNC. In another less complex method which conserves resources, the selected PLMN is indicated by a reference association with the transmission of the additional PLMNs on the BCCH. For example, an 8-bit sequence of 3 bits can be used to address 8 different PLMNs. The reference could refer hereby, for example, to the sequential order in which the PLMN IDs are transmitted on the organization channel BCCH. For example, if the three PLMNs (PLMN0, PLMN1, and PLMN2) are transmitted on the organization channel BCCH which jointly use the radio access network 12, then a bit sequence of "010" would indicate that the subscriber terminal 13 requests connection to PLMN2. Support of up to 8 core networks (similar to 10 or 11) is sufficient for practical applications and from an operative standpoint. However, the method can advantageously be used for any number of supported core networks or mobile radio providers. In another alternative

embodiment, a single bit can be used to indicate the "default" core network, which can be derived directly from the IMSI ("International mobile subscriber identity") of the subscriber terminal. An optional signaling default ("yes"/"no") would then have to be included in the signal transmission from the subscriber terminal to the mobile radio access network, whereafter the RNC sets up the connection with the core network or the network operator based on the IMSI of the subscriber terminal. Default signaling or complete signaling of the desired core network (mobile radio provider) can be controlled on the organization channel (BCCH) of the radio access network, for example, by a single bit or by another implementation.

[0036] With the method of the invention, different core network parameter sets can be provided by using additional System Information Blocks (SIB1) on the organization channel BCCH of a mobile radio network. This information may include, for example, information required for communication with the core network which may be different depending on the type of the core network. Additional BIB1s (e.g., SIB1.1, SIB1.2, etc., or SIB1bis, SIB1ter) must then be set up on the BCCH, by which a dedicated set of (potentially different) core network parameters for each of the supported core networks 10 or 11 can be provided to the potential subscriber terminals 13 via a common radio access network 12, as shown in Fig. 4e and Fig. 4f. Based on the selection of the mobile radio operator on the basis of the PLMN IDs 14 transmitted in the common radio access network 12, the subscriber terminal 13 reads only the required information for the selected PLMN from the respective SIB1.

[0037] In an alternative embodiment of the inventive a method, one or several alternative dedicated mobile radio network operator IDs (PLMN IDs) are provided (as in 14). In this case, the organization channel BCCH of the radio access network 12 is not used to transmit additional PLMN IDs, but the information about additional possible PLMNs is instead provided to the subscriber terminal 13 by using, for example, one of the subscriber terminal - network communication procedures commonly used in GSM or UMTS, such as the registration procedure, the "PDP context activation" or the "location registration" procedure. With the novel method of the invention, the additional mobile radio operator IDs for each individual mobile radio terminal 13 can advantageously be transmitted separately, and the corresponding lists of the potential mobile radio network

operators for each subscriber terminal-network association can be provided.

[0038] In principle, different possibilities exist for additional use of the information about additional mobile radio operators:

[0039] For example, a subscriber terminal 13 can receive information that a group of mobile radio networks (PLMNs) can be regarded as a common network. The subscriber terminal 13 can then switch between cells in different radio access networks based on the "cell reselection" parameters transmitted on the organization channel BCCH, for example according to the UMTS or GSM standard, in the same way as if these cells were to belong to a single mobile radio access network 4, 5 or core network 1, 2 (mobile radio operator).

[0040] In an alternative embodiment, the information transmitted to the subscriber terminal is used for selecting and transmitting the connection request in the same manner as described above with reference to Fig. 3. The information about the connection request with another mobile radio network operator would be indicated 15 to the registered mobile radio network operator (actual operator), who would then be able to provide access to the core net of another mobile radio network operator via his own radio access network. Alternatively, the services could also be provided by the actual registered mobile radio network operator, however, the services would then be reconciled based on the transmitted connection request (like a "call-by-call" for mobile radio services). Similar methods are presently used in landline telephony where the actual core network operator is selected by transmitting a specific "pre-prefix." For example, the radio access network control unit (RNC or BSC) can use transmission of the desired mobile radio network operator ID (PLMN ID) according to one of the aforedescribed methods to set up the corresponding connections to one of the possible core networks in accordance with the selection, or this information can be processed in the billing system of the mobile radio provider.

[0041] Lists of reference symbols

1. core network operator A
2. core network operator B
3. interface (Iu or A interface)
4. radio access network operator B
5. radio access network operator A

6. core network operator A
7. core network operator B
8. interface
9. common radio access network
10. core network operator A
11. core network operator B
12. common radio access network
13. subscriber terminal
14. transmission PLMN ID
15. selection PLMN